TARGET STATION B

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1220

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I. General Description

The principal aim of this target station is to obtain several beams, independently controllable in momentum and polarity, from one target in the EPB. This is to give maximum flexibility to the users of the type usually associated with internal target areas of existing accelerators. The method is to place a multiple collimator (a block of material with several holes for beams) a short distance downstream of the target; small angle production (down to $\sim 2\frac{1}{2}$ mr) can be obtained, but 0° production is not possible. Although 0° gives the highest flux of secondary particles, it is felt that the small, non-zero angles used here are not a serious disadvantage. A big advantage of not taking 0° production is that the main beam, and most unwanted secondaries, are stopped in the collimator block, giving pions produced in the target only a short distance in which to decay to muons. Because of this, the serious problems in many EPB target station designs, namely of enough shielding to stop a large flux of muons, is not present here; thus the shielding can be comparatively simple and easily arranged to suit changing experimental requirements.

In the arrangement described here, 6 secondary beams are shown, although the system can be easily extended to a large number. Each beam must be separated from its nearest neighbors by ~ 5 mr in production angle.

II Production Target and Collimator Block (See Fig. 1)

The production target is shown as 30" long; questions of its optimum material, support and cooling are not discussed here. The length certainly could be increased but at some point will produce problems regarding the optics of the widest angle beams.

The production angles chosen are $\pm 2\frac{1}{2}$ mr, $\pm 7\frac{1}{2}$ mr, $+12\frac{1}{2}$ mr and $+17\frac{1}{2}$ mr, although these figures are not rigid. Downstream of the target is the collimator block, which is a block of material (type of material not specified, possibly iron or uranium) with several accurately machined holes in it. The distance from target to collimator was chosen as 120", so that the hole separation at the upstream end is a reasonable distance (0.6"). The machined block, which could have a cross-section as small as ~15" H x 3" V, is embedded in iron, etc., shielding and can be replaced fairly simply by another with different holes when required. The ~300" length is set largely by the quadrupoles following it; these are placed as far upstream as possible to obtain large solid angles and the collimator block extended to almost touch them. The quadrupoles have 1" diameter aperture, which gives a collimator hole size 0.3" diameter at the entrance and 1" diameter at the exit. (Note that the collimator bore need not be conical but can be stepped cylinders.) A long collimator has the advantage of stopping the EPB and its secondaries, including muons, more effectively.

Quadrupoles

These are based on a design by A. Maschke, and their cross-section is shown in the insert in Fig. 1. Their I.D. is 1", O.D. 2" H x $5\frac{1}{2}$" V, and length 48". A doublet is used on each beam (first quadrupole vertically focusing, as this gets largest flux), with spacing 48" (N.B. The optics of these beams have not been studied in detail). The quadrupoles produce a parallel beam, though if the dispersion in the larger bend beams is too great (not checked), the quadrupoles can be used to produce an intermediate focus halfway along the magnet system described in the next section. If this is not enough, some extra quadrupoles would have to be placed part of the way along the magnet system.

III Bending of Beams (See Fig. 2)

The separation of the beams at the exit of the collimator block is small (~2"); this separation is increased and the particle momentum defined by a series of bending magnets in each beam. These septum magnets (designed by A. Maschke and shown in the insert of Fig. 2) have an aperture 2" H x 1" V, and produce a 9-Kg maximum field. The bending angles chosen to give good physical separation between the beams are given in Table I; to obtain reasonable bending for the higher momentum beams, 2000" of bending magnet were chosen, which defines the maximum possible momentum for each beam as given in Table I.

The positioning of the magnets is such as to "peel off" the two outside beams first and then, when the separation is great enough, magnets are inserted to "peel off" the next pair of beams. This gives ~20' displacement between adjacent sets of magnets as shown in Fig. 2. As the beams become more separated, larger aperture magnets can be used; this may also be necessary due to dispersion causing a larger beam cross-section after several magnets. The magnets are shown as 200" long as this is the length whose aperture can just contain a 1" diameter beam when the total bend is 12°. For practical reasons, the magnets can be shorter than this.

Downstream of the magnets, a pair of quadrupoles focus the beam on to the momentum defining collimator. These quadrupoles can be (and probably will have to be due to dispersion) of standard size, ~4" I.D.

IV Overall Target Station Layout (See Fig. 3)

Heavy concrete shielding is inserted between the different beam lines as far upstream as possible; in the forward direction, the shielding is iron to cut out any remaining muons. The shielding shown (see also the insert in Fig. 3 for the vertical section) appears to be adequate from curves given in the ECFA reports, though this has not been checked in detail; some more iron may be necessary in the forward direction. Downstream of the collimators, only minimal shielding should be necessary, analogous to that for beams outside the main shielding wall of internal target areas at existing accelerators.

The cost of the magnets and quadrupoles is estimated to be ~\$720K, and the maximum power consumption ~4.4 Mw (both estimates from A. Maschke). The floor area shown in Fig. 3, if made of concrete of strength comparable to that of the floor of experimental areas of existing accelerators, would cost ~\$200K (estimate by W. Salsig).

Not resolved at the present time is the building to cover this area; a crane capable of lifting ~30 tons will be necessary for changing shielding, etc., configurations. W. Salsig has some ideas on this problem.

V. Experimental Beams from this Target Station

An estimate has been made by L. Koester of the maximum useful momentum of each of the beams. Taking the solid angles to be defined by the quadrupoles shown in Fig. 1, he calculated the maximum momentum that would give $\sim 3 \times 10^5$ pions for 10^{12} protons in the EPB. These maximum momenta are given in Table II.

To obtain some idea as to possible experimental beam configurations from this target station, the beams described in Table III have been considered (A.L. Read); they are shown schematically in Fig. 4. Approximate costs and maximum power consumptions (from H. Blewett) for these beams are given in Table IV.

No study has been made of buildings, crane coverage, etc., for these beams. However, if the whole area shown outlined in Fig. 4 were to be surfaced with concrete, of strength equal to that of experimental areas for existing accelerators, the cost would be ~\$2M (W. Salsig).

References

All references are to private communications from the persons named.

TABLE I

Production Angle (mr)	Bend Angle (degrees)	Max Possible Momentum (GeV/c)
2.5	3.0	260
7.5	6.0	130
12.5	9.0	90
17.5	12.0	70

TABLE II

Production Angle (mr)	Max Useful Momentum (GeV/c)
2.5	130
7.5	100
12.5	70
17.5	50

TABLE III

Beam #	Production Angle (mr)	Beam	Reference
1	7.5 left	20 GeV/c unseparated or electrostatically separated	Ely.B.B. Fig XIII-15
2	2.5 left	50-150 GeV/c unseparated	Longo. Y-1-137
3	2.5 right	"	"
4	7.5 right	25-75 GeV/c unseparated, high intensity	"
5	12.5 right	15-50 GeV/c R.F. separated	Bernard. G-2-63
6.	17.5 right	20 GeV/c unseparated or electrostatically separated	Ely.B.B. Fig XIII-15

(Y=yellow LRL books; B=blue LRL book; G=green ECFA book)

TABLE IV

Beam #	Approx cost (M$)	Approx max power consumption (Mw)
1	0.5	10
2	2.0	3
3	2.0	3
4	2.0	2
5	4.0	10
6	0.5	10
Totals	11.0	38